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Annual Review of Literature (1952)

on

Water Pollution

NATIONAL TECHNICAL
INFORMATION SERVICE

by

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*An annual review prepared for the

Research Committee

of the

Federation of Sewage and Industrial Wastes Associations

Abatement and Control

General interest in the problem of abatement and control of water pollution has increased during the past year. Schwob and Dworsky[1] review the program of water pollution control in recent years and state that the Water Pollution Control Act of 1948 authorizes the Public Health Service to initiate the development of programs for water pollution abatement. Pirnie[2] stresses that any development in waste treatment must be worth what it costs. National water resources policy relating to stream pollution is discussed by Howson[3]. Present pollution controls are believed adequate with control invested in the lowest level of government having jurisdiction over the stream. Wieters[4] reviews the cooperative activities of the state and federal governments under the Water Pollution Control Act of 1948. Several articles appear in the literature[5][6][7] which summarize in general new construction of waste treatment facilities and techniques and trends in water supply and sanitation. Schwob[8] states that efforts to abate pollution will proceed from the "fact finding" to the "practical" stage during 1952. He mentions that there are 22,000 significant sources of pollution listed for the nation with 11,800 municipal and 10,400 industrial sources. Murdock[9] discusses industrial waste pollution and its relation to Southern watercourses. He states that the Southern Association of Science and Industry is taking steps to assure that Southern streams are kept sufficiently clean for the needs of industry, agriculture and the public.

A review of the water pollution control problem from the point of view of the refinery operator is presented by Nord[10]. He discusses the nature of pollution, types of contaminants (especially oil and phenol), measurement of pollution, stream purification processes and factors, plant survey and treatment, and legal considerations. Barron and Henderson[11] review the current literature of sanitation recommended for the engineer's bookshelf including water supplies, stream pollution, sewerage and sewage treatment and industrial wastes.

Hollis[12] stresses the need for more study on physiological and toxicological effects of both inorganic and organic chemicals in water supplies. He mentions the membrane filter for bacteriological control and techniques for recovering organic chemicals from water for study. Greenburgh[13] discusses the pollution of rivers from the aspect of preservation of fish life. He suggests procedures for sampling river water and observations to be made when loss of fish has occurred in relation to subsequent legal action. Hoak[14][15] discusses theory and practice in stream pollution control and stresses that the streams themselves provide the final criteria of what may be discharged to them.

A number of reports in the Public Health Service Water Pollution Series which were released are the summary reports for the following drainage basins: Western Gulf Drainage Basin[16], Southeast Drainage Basins[17], Western Great Lakes Drainage Basin[18] and Upper Mississippi Drainage Basin[19]. These cooperative state-federal reports summarize information relating to uses of water resources, pollution contributed to

streams, damages to streams from pollution, benefits resulting from pollution prevention and abatement, pollution prevention measures in effect, analysis of state water pollution control legislation and pollution prevention measures required. Reviews of the previously listed Summary Reports and, in addition, reviews of the New England, Lake Erie, Ohio River, North Atlantic and Colorado River Drainage Basins are presented in the literature(21)(22)(23)(24)(25).

The Ohio River Valley Water Sanitation Commission in its fourth annual report(26) reviews the activities during 1952 of the eight state commission with description of the projects undertaken, methods of operation, progress made and objectives of the commission. The commission again voiced support of fast depreciation privileges for industries who must build costly treatment facilities for the prevention of stream pollution(27). It recommends passage of legislation amending the Internal Revenue Code to permit a five year write-off of pollution control facilities rather than over the useful life of the equipment to provide an incentive for industrial waste pollution abatement. The Commission attended ground breaking ceremonies at Bromley, Kentucky for a new sewage treatment plant for the Northern Kentucky Sanitation District No. 1 comprising 16 separate communities(28)(29). The treatment plant will receive wastes ffom a considerable amount of industry and 136,000 people.

The Allegheny County Sanitary Authority is 12-months behind in drawing detailed plans and specifications for a $60,000,000 sewage treatment system for Pittsburgh and 64 other municipalities(30). Only

sewage originating in Alleghany County will be handled by the system. The system can do nothing for the acid coal mine drainage and other pollutants already in the rivers. A $17,500,000 project unifying treatment of sewage in the Colne River Valley (England) and rendering obsolete 26 outgrown systems was officially opened[31]. It serves a third of a million people and drains an area of 150 square miles with some 55 miles of trunk sewers. Ramshorn[32] discusses the magnitude of the water supply and effluent problems in the Ruhr region. Associations have been formed to supervise purification plants on the Ems, Ruhr and Lippe Rivers. Self-purification has been increased on the Ruhr River by building dams and installing pumping plants to pump water from one reservoir to another upstream reservoir, thus increasing detention time.

A number of articles appeared in the literature concerning the progress of the Middlesex County Sewage Authority in its efforts to obtain the necessary backing for its project to clean up the Raritan River[33][34][35][36][37]. Since it failed to obtain the 90 percent of potential financial support needed from industry and municipalities to go ahead with its project, a partial plan was refigured. The new plan will cost $25,000,000 and the authority pledges a prompt start on the new project, a 21-mile interceptor and a 70 mgd primary treatment works instead of 27-mile and 95 mgd as originally planned.

Lowe[38] describes the water pollution situation on the Rio Grande River in New Mexico. Silt loads, milling of radioactive ores, production of radioisotopes and the increases in population are the important pollution problems in the basin. Two drainage basin reports were

released by the New York State Department of Health[39][40]. One concerns the Allegheny River Drainage Basin and the other the Lake Erie, Niagara River Drainage Basin. Hess[41] in an Interstate Sanitary Commission Report summarizes the industrial waste discharges from 306 plants distributed along 1500 miles of shoreline in New York, New Jersey and Connecticut. By mid-1954 there will be practically no raw sewage in any Class A (recreational) waters of the Interstate Sanitary Commission's area[42].

The need for a more complete definition of rights to water in relation to the many variable conditions of its uses because of the increasing use of our water resources is brought to our attention by Harding[43]. He suggests that problems should be solved without major modification of present water law concepts with future changes in water law amplifying and refining rather than revising fundamentals. The author discusses the riparian rights doctrine and the appropriation system and summarizes the methods for acquirement of new rights, determination of existing rights and administration of water rights.

The State of Ohio's new Water Pollution Control Act of 1951 went into effect September 27, 1952[44]. The new act gives a 5-man board authority needed to abate pollution including investigation, research and education. Robinson[45] reviews the discussion on the new pollution control law at the Ohio Conference on Sewage and Wastes. McDill[46] discusses the status of the Ohio State Department of Health and the organization and activities of its water pollution control unit in relation to legislation concerning control of pollution of surface waters.

Waring[47] states that adequate surveys are needed to find all areas where treatment of sewage and industrial wastes are needed. He also discusses the Ohio pollution control legislation and the financing of new works. Maryland law and policy relative to stream pollution are summarized by McKee[48]. A review of legislation created by the 1949 California Legislature is presented[49]. The legislation established by definition the concepts of "contamination", "pollution", and "nuisance". Control is based on a case by case study and analysis of water uses rather than by a fixed rule. Baigus[50] presents an outline of the New York State pollution law and a discussion of how the law operates. Since surveys and classifications of the state's waters will not be completed until 1963, no enforcement is forseen until then. Weiss[51] presents a state-by-state summary of anti-pollution legislation including penalties, quality standards, and special requirements. Interstate and federal pollution control is included. He also furnished the water quality criteria adopted by several interstate agencies and the composition and addresses of State water control commissions. A report[52] on the pollution of waters in New Zealand by a committee appointed by the Dominion Government was released and a review of the report appears in the literature[53]. The report directs attention to significant conclusions regarding the effectiveness of present laws, their administration, and the consequent results of pollution.

Legislation in France for the protection of navigable waterways, standards for drinking water, control of industrial development in relation to stream pollution, and municipal control of pollution are discussed by Kempf[54]. He also discusses further aspects of legislation in France

to protect fish in streams from the harmful effect of industrial wastes. Walker(55) presents a resume of statutes controlling pollution of the Thames River.

In Ohio, industry's representatives were warned(55a) against a "program of fighting retreat" by Attorney General C. Williams O'Neill who charged that stalling on effluent cleanup is asking for legal action. Cleary(55a) refuted the "erroneous impression" that industry will shy away from states with rigid clean streams legislation. Youngstown was charged with breaking the anti-pollution law of Ohio by emptying raw sewage in the Mahoning River(56). The Pennsylvania State Sanitary Water Board asked the prosecution of 37 communities in the Susquehanna River Basin which includes the Juniata River and its tributaries(57). The cases of 35 other municipalities in the Susquehanna basin which are in various stages of progress will be reviewed by the Board. The Pennsylvania State attorney general asserted that action would not be taken by his department to prosecute the cited 37 communities until all other means of persuasion had been exhausted(58). The attorney general said that his order for re-examination did not constitute a change of policy in the state's clean streams program(59). Wisconsin's State Committee on Water Pollution issued orders with time limitations for compliance to 85 pollution offenders in the Rock and Sheboygan River Basins(60). There are many milk receiving stations, canning plants and metals and textile industries on the Rock River while the Sheboygan River passes through one of the largest cheese producing areas in the State before emptying into Lake Michigan. The State of Oregon softened its crackdown on pulp and

paper makers because of progress and effort made to date[61]. It was reported in the same article[61] that the Virginia State Water Control Commission has gone on record against the Public Health Service program as a duplication of State measures in stream pollution control.

The city of San Jose lost a court decision to the Leslie Salt Company on the city's condemnation procedure to acquire 1865 acres of bottom land for construction of sewage oxidation ponds, which the Leslie Salt Company had been using for salt production[62]. The Court's decision was determined by the failure of the city to prove that the large tract of land was necessary for the purpose or that it would be used to best advantage. The case of 10 city officials of Vernon and Culver City, California, cited for contempt of court two years ago, because their cities failed to contribute to Los Angeles' Hyperion Sewer Project, will be reviewed for the third time by the State Supreme Court[63]. If the State Supreme Court upholds the judge's original ruling as it has twice before, the defendants will be jailed for 5 days and will pay $500 each. The city of Durham, N. C. settled for $35,125 eleven suits seeking damages totaling $148,500[64]. The suits were instituted several years ago by landowners adjoining Ellerbee Creek which receives overflow sewage from the Northside Disposal Plant. The landowners claimed the overflow constituted a nuisance and damaged their health. The city agreed to remedy the situation.

Hopmans and Bos[65] discuss the fight against pollution in the Twenthe basin. The measures required to prevent pollution in the basin and construction details of the Enschede biological filtration plant are

given. Newcombe[66] discusses aspects of water pollution study in the California and Great Basin Area.

Pollution control through the establishment of classes and standards is receiving increased attention. Several articles appeared in the 1952 literature relating to classification and standards. Phelps[67] proposes a system of stream classification based on "best usage", and the establishment of quality specifications for each class. These include a stream survey and cost considerations. Dappert[68] lists a number of principles that should be observed in developing a classification standard system for pollution control. A brief lecture on the classification of industrial effluents, their effects on streams, water supply in relation to pollution, and commercial uses of stream water is presented by Lovett[69]. A report of the Mersey River Board for 1951-52[70] divides rivers into "industrial" and "fishing" categories. It states that there are 89 different industries producing waste effluents in the Manchester area alone and pollution from such diverse wastes makes ordinary standard tests valueless. The Rivers Act, 1951 (Great Britian), set up river boards and empowers them to make surveys and to prescribe standards for both domestic and industrial effluents[71].

McCabe[72] discusses the inter-relation of air pollution and water pollution. Other reviews[73][74] stressed the factors involved and the methods employed, the sources and characteristics of pollutants, sampling and metering techniques, regulations and organizations of water pollution control boards.

Pollution of ground water is a serious problem in certain sections of the world. Articles in the literature describe problems in Michigan[75] with pollution of ground water by small industries and oil and gas field brine and in the British West Indies[76] sewage is disposed of by pumping into borings in the coral strata.

Several articles in the literature stress the importance of stream pollution evaluation and the methods employed. Hedgepeth[77] discusses the difficulties involved in measuring pollution in order to fix standards of treatment. He stresses that no method is universally applicable and that each case must be judged on its own merits. Corti[78] discusses the conditions of modern life in Switzerland which are making it important to develop methods of protecting surface and ground waters from pollution. He discusses the requirements of a satisfactory domestic supply, the constituents of industrial wastes which cause special difficulty with the limitations of water treatment methods which are economically possible and the present and proposed future legislation of Swiss law on the protection of waters.

Akerlindh[79][80][81][82] has written several articles relating to storm water flow and runoff, required regulated flow and its determination when discharged into lakes.

A series of industrial waste conferences was established under sponsorship of Duke University, North Carolina State College and the University of North Carolina in 1952[83]. The annual conferences will be integrated with the schools for sewage and water plant operators which the three

institutions conduct each year. The symposium of stream pollution and industrial waste at the A.A.A.S. meeting in Philadelphia is reviewed in the literature(84).

Omaha, Nebraska started dumping its garbage, amounting to about 80 tons, in the Missouri River because a hog epidemic caused a quarantine and slaughtering of more than 10,000 animals which removed the hog market for consumption of the garbage(85). No funds were available for a landfill. Later(86), arrangements were made with the Central States Corporation on a $2500 monthly subsidy to process the garbage into animal food which will be sold for about $30 a ton. Mooser(87) reviews the various types of diseases which may be spread by water with reference to some classical epidemics from which the relations between water and disease were deduced.

The occurrence of contamination from the surrounding watershed of an open reservoir is described by Franeuf and Healy(88)(89). A service reservoir for Concord, N. H. was contaminated by fecal deposits from picnickers. Methods of control and treatment are presented. Decontamination required two weeks' time. Draemel(90) describes the silting of rivers in Pennsylvania resulting from widespread cutting of forests which led to rapid water run-off and heavy soil erosion. In addition, the rivers are polluted with industrial wastes, particularly from mines. He discusses the methods used in the conservation of rivers, especially the Schuylkill.

Some examples of the possible use of controlled pollution for improving streams are described by Murdock[91][92][93]. He discusses the control of aquatic vegetation in waterways by various chemicals[91]. Only sodium arsenite has given good control with low fish toxicity and a low price. He cites[92] the use of decaying vegetation in experiments at Oklahoma A and M to be satisfactory in removing clay turbidity from ponds without excessive depletion of dissolved oxygen or destruction of fish life. The author[93] also mentions the possibility of using the citrus fruit wastes as a source of vegetation whose decay might be used in settling the turbidity in streams from clay-phosphate slimes in the Florida phosphate rock industry.

To reduce the pollution in the Buffalo River by dilution is the aim of five companies in the Buffalo, New York area[94]. They are teaming their resources to pump Lake Erie water for plant use which will be then discharged to the Buffalo River.

The disposal of wastes at sea by barge is not new with records of such practice dating back to the 14th Century[95]. The National Lead Company which disposes of a waste containing 10 percent $FeSO_4$ from a barge at 6-15 feet below surface in the turbulent zone of the wake of the barge ascertained that acidification of sea water was short lived and no biological damage resulted from its waste disposal[96]. The county sanitary districts of Los Angeles County have conducted weekly surveys of the ocean waters in the vicinity of White's Point Ocean Outfall which is discharging primary effluent 5,000 ft. offshore at a

depth of 110 ft.[97]. These surveys have been conducted for the past 18 years excepting 3 war years. Information is being obtained regarding shore-line bacteriological activity and the factors which influence the spread and dilution of the sewage field.

Regan[98] sketches briefly the history of the disposal of the sewage of London and follows with a description of the field work conducted from 1893 to 1952. Some of the factors which affect the condition of the tidal portion of Thames River are presented and the results of 60 years of systematic sampling are summarized with tables. Since the dissolved oxygen content at the Southern Outfall has been practically zero since 1946, the London County Council is considering various plans for addition to the works so that some dissolved oxygen may always be present in the river off the outfall works. Mills[99] presents a step by step method for performing a pollution abatement program in tidal waters. The program is illustrated by its application to oil refinery wastes.

The problems of industrial waste disposal and pollution abatement are interdependent especially when critical conditions exist. One method of improving the situation is by effecting pollution abatement through water conservation and Hauck[100], Fox[101], and Howell, et al[102], discuss this method. Reuse combined with waste treatment is the key to water conservation.

A report on treatment requirements for sewage discharged to the Ohio River between Huntington, W. Va. and Cincinnati, Ohio was released by the Ohio River Valley Water Sanitation Commission[103] and a review of the report appeared in Sewage and Industrial Wastes Journal[104].

The Public Health Service[105] reported that municipalities in 33 states have awarded contracts for the construction of 111 sewage treatment plant projects during the first quarter of 1952 involving $27,000,000. Of the projects, 72 are new plants costing a total of $17,000,000 and the remaining 39 consist of additions to, or replacement of, existing plants. Facilities to serve almost a million people were either completed, under way, or approved in the plan stage to alleviate Ohio valley pollution with the report[106] stating that 22 new plants were in operation, 25 plants under construction, and 47 final plans approved. The Tennessee State Stream Pollution Control Board[107] has announced that about $26,800,000 of new sewerage facilities are either under construction or in the planning stage in a number of Tennessee cities. The board has placed five cities on notice to either comply with its regulations dealing with stream pollution control or show cause why this has not been done. A $25,000,000 program for modernization of the Seattle, Washington sewage disposal system which would continue use of Puget Sound as a disposal area has been presented to the mayor and the city council[57]. There would be four primary treatment plants, 29 pumping plants and approximately eight miles of interceptor and replacement sewers over a 10-year period. A long range program was outlined for Los Angeles[108] involving $21,000,000 of construction in the next five years and another $20,000,000 over the next twenty-five years. Charleston, W. Va.[109], expects to get a $12,000,000 job of overhauling its inadequate sewage disposal system underway this summer. The job includes a $10,000,000 ultra modern disposal plant that would prevent

further pollution of the Kanawha and Elk Rivers. The other $2,000,000 would go for additions to the present city-wide drainage system. The Pennsylvania State Supreme Court gave Scranton its favorable decision for the program of setting up a municipal sewer authority to handle construction of sewer systems(110). The authority will supervise building the proposed $8,000,000 sewage disposal system. The end of the discharge of raw sewage into Biscayne Bay is in sight now that Miami property owners have voted $27,000,000 to clean up the Miami River, the Intercoastal Waterway and the Miami Beach side of the bay(111). The present sewer system discharges an estimated 47 mgd of raw sewage into Biscayne Bay and the Miami River through 70 outfalls. The construction of an underwater pressure sewer across the bay to Virginia Key, a sewage treatment plant on the Key, an underwater outfall sewer 4,500 feet out into the Atlantic Ocean and interceptor sewers and pumping stations on the mainland are included in the plans. The completion of an $18,000,000 sewer project at Portland, Oregon will end the discharge of sewage into the Willamette River(112). Sewage will be carried from the city and industries to a new disposal plant on the bank of the Columbia River. Discussion regarding payment for a $12,000,000 sewage treatment plant to reduce pollution of the Ohio River still continues between the city of Louisville, Kentucky, and the Louisville Metropolitan Sewer District(113). The District suggests that the city issue bonds to pay for the plant. The city refuses to do so as they see no reason why they should finance a plant which will treat sewage from outside as well as inside the city limit. The city claims the financing is the District's

responsibility. It is planned to construct primary treatment facilities for wastes with a P.E. of 335,000 at Nashville, Tennessee so that secondary facilities could be added at any time(114). Revenue bonds in the amount of $11,000,000 were voted for the necessary sewerage facilities.

The H. J. Heinz Co. which is under a State (Pennsylvania) order to correct its seasonal pollution of Conochocheague Creek in Chembersburg has operated a 20 gpm pilot plant during the 1951 canning season which indicated that biosorption would be effective(115). The cannery's old waste facilities are being modified to take the full waste flow from the peach, tomato and apple canning seasons. An "experimental" permit has been issued by the Pennsylvania Sanitary Water Board until the plant has operated a sufficient time to demonstrate that it deserves full approval. McCracken(116) describes the pollution abatement program at DuPont's Waynesboro plant. In a 5-year program the water borne wastes from an acetate rayon plant were reduced from about 12,000 lbs. B.O.D./day to 3,700 lbs./day while plant production was increased 50 percent. The reductions were accomplished by alteration of processes, recovery and recirculation. The Hiram Walker and Sons distillery at Windsor, Ontario(117) are spending $1,500,000 to curb pollution of the Detroit River. They are converting stillage from 5,000 bushels distilled mash into distillers dried grains and dried solubles used as stock food. Revenue from the products are expected to cover the cost of recovery.

Not only has a serious pollutant been arrested but a substantial return is being realized in reclaimed tonnages of marketable coal, as about 6,000,000 tons of coal as fine sizes and silt are collected each year by treatment plants at all 173 anthracite collieries in Pennsylvania[118]. Successful coal pollution removal is evidenced by reduction in water treatment costs for cities that use the Schuylkill River for a public water supply and the return of fish to waters that they have avoided for years. The acid mine waste problem still has not been solved. A report[119] on the Schuylkill River cleanup states that the removal of 38 million tons of silt, removal of old dams, construction of new dams, channeling and desilting basins will cost nearly $32,000,000. Hebley[120] reviews the practice for treating waste waters from anthracite mining in the State of Pennsylvania in detail. He states that the treatment of effluents from the washing of bituminous coal is complicated because acid waters may be formed by reaction of pyrites with carbonaceous materials. Coal mine operators have agreed to defray half the cost of research done on the problem of stream pollution from acid drainage for a project underway at the Mellon Institute in Pittsburgh from which practical results are expected[121].

A review[122] of a New England Interstate Water Pollution Control Commission report appeared in the literature. The Commission states that industrial leaders have yet to assume their full responsibility in the pollution abatement and control program. The report put the industrial load in the Commissions area from 1,939 plants at a P.E. of 4,934,820 of which 93.4 percent is discharged untreated. Dooms[123]

reports on a conference on the occurrence of pollution in the rivers Yser, Lys and Upper Escaut in Flanders and discusses the measures to reduce pollution, particularly from industrial wastes. Hedgepeth[124] presents an essay on pollution problems in industry with the emphasis on his interpretation of realism vs. dogma. Mohlman and Southgate[125] discuss the disposal of industrial waste waters in the United States and in Great Britian, respectively. Mohlman discusses the treatment of wastes mainly in the Sanitary District of Chicago including wastes from slaughterhouses, coke-oven plants, starch industry, manufacture of antibiotics, and the pickling processes of the steel mills. Southgate reviews the legal aspect of industrial waste disposal in Great Britian, the removal of Cu from waste pickling liquor by electrolysis, the removal of CrO_4 from anodizing baths, the removal of CN^- from electroplating wastes, the removal of cutting oils, the reuse of waste liquors after a certain degree of treatment and the treatment of gas works liquor.

Roberts[126], in a collection of published papers on the disposal of metal processing waste effluents, outlines legislation in the U.S. concerning industrial waste pollution and discusses treatment methods for cyanide wastes and pickling wastes from metal plating processes. Wise[127] reviews water pollution control and recent research into the application of ion exchange processes using synthetic resins, natural clays, etc. for the treatment of industrial wastes, especially those from the metals and plating industries. Considerable savings in water

consumption can be obtained by waste treatment. A process of treating waste chromium from anodizing baths by a combination of ion exchange resins with the effluent returned for reuse is described(128). Installation costs are 50 percent below conventional treatment, operating costs lowered 75 percent, 80 percent less flow space required, scarce materials consumption reduced by 90 percent, water and steam reduced 85 percent with better finished products obtained and chromium ions to sewers reduced to a low level. The value of CrO_3 lost per day before treatment was $33, after treatment, $3. The total chemical costs before treatment was $63 and after treatment, $17 per day. Prevention of wastes as a solution to air and stream pollution from the mineral industries is discussed by Boyd(129), with reference to the possibility of recovering sulfur from fumes, Mn from Mn ore processing, rare elements from flue dusts and smelter discharges. He also discusses wasted heat from fuels and wasteful practices in petroleum refineries. U. S. Steel's Fairless Works in Morrisville, Pennsylvania is the largest integrated steel mill to be built at one time and is the first with waste disposal built into the operation(130). The wastes will be clearer than the Delaware River which receives them. The alkaline wastes neutralize acid wastes, acid wastes dissolve scale and sediment, the wastes in general are put to work.

There has been some significant activity in the paper and pulp industry in adapting new processes for pollution abatement. Measures to overcome pollution by pulp and paper mill effluents and other industrial wastes are discussed in an article(131) in relation to stream

improvement in Florida. Some of the activity may derive from the rulings of several State pollution control commissions reported by Murdock(132) that pulp and paper mills must substantially reduce pollution nuisances in streams in Wisconsin, Washington and Michigan. Murdock(132) states that the commissions know that available equipment can effectively remove suspended fibers, precipitate certain substances and remove the floc from the wastes before they are discharged. He believes commissions must consider each mill individually since old mills, for example, can not be expected to discharge effluents as clean as more modern mills. However, industry must realize that public opinion will not tolerate pollution. Several of the advances made in pollution abatement in the pulp and paper industry are reported in the literature(133)(134)(135)(136)(137). Four Wisconsin sulfite mills are adopting the Conkey Flat-plate (Rosenblad) evaporator for concentrating waste sulfite liquor so it may be burned(133). The Crown Zellerback Corporation's ammonia process also yields a product that can be burned(133) or used(135) as an adhesive, wetting agent, dispersant, soil conditioner, yeast nutrient and as raw material for organics. Corrosion resistant evaporating equipment has been installed at a Lebanon, Oregon mill. The recovery or production(136) of vanillin, tall oil, sulfur and other chemicals from wastes have demonstrated value, with other items as good possibilities. The Rhinelander Paper Company, Rhinelander, Wisconsin(137) started its million dollar plant to concentrating sulphite liquor wastes. Over 60 of the 90 tons of waste produced are recovered.

Pollution abatement by the petroleum industry and by industry using soluble cutting oils is described in several articles in the literature[138][139][140]. The wastes from the Cadillac Motor Car Division of General Motors Corporation located in southwest Cleveland contains soluble oils from machining operations, these oils being discharged as emulsions[138]. The waste is treated chemically, filtered, aerated and chlorinated to meet the waste standards set by the Cleveland Metropolitan Park Board. These standards are presented in the article.

The pollution problems in the disposal of wastes from coke- and gas-works are discussed in several articles[141][142][143]. Disposal of effluent by evaporation, recovery processes, destruction of phenol by ozone, discharge to sewers and biological treatment are discussed. Stream pollution in relation to tannery wastes is discussed in several articles in the literature[144][145][146] and the importance of treating these wastes stressed. Pondaven[147] discusses the pollution of streams by distillery wastes and Coogan[148] presents factors which influence pollution problems associated with the operation of sugar factories. A program of surveying stream conditions to determine the effect of grinding operations on water in streams is being conducted.

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Bacteriology

During the year several investigators have reported the isolation of pathogenic bacteria from the water of polluted streams. Moore, Perry and Chard[1] repeatedly recovered "Paratyphoid bacilli" from a river flowing through a town of 10,000 inhabitants. Two Paratyphoid B carriers and one typhoid carrier were discovered by systematic swabbing of sewers and modern culture techniques. These methods can be applied to the elucidation of unsolved enteric outbreaks and to the control of food-handling establishments.

Lendon and MacKenzie[2] isolated Salmonella typhosa from the water of Wallington River, Hants. The source of the organisms was traced to a carrier by use of Moore's swab technique. Samples of river water collected after a storm showed the presence of Salmonella. Further tests proved that the bacteria were being discharged from the storm overflow of a combined sewage system serving Purbrook.

S. typhosa and S. paratyphosi B were identified from the processed sewage effluent of Hanover, Germany by Messerschmidt and Wedemeyer[3]. At the point of discharge into the Line River, 21 of 45 effluent specimens were found to contain Salmonella. Of 25 specimens taken from the river up to 3 miles below the outfall, 5 contained Salmonella. The sewage disposal plant consisted of a grill, a sand filter, and a sedimentation chamber, and had a total passage time of about 90 minutes.

A new Salmonella type was recovered from the water of Mendoza River by Leiguarda et al[4]. It was named S. mendoza and belonged to group D of the Kauffmann and White schema with the antigenci formula IX, XII, 1, v, -1, 2 ----, accidental ingestion of the organism was followed by enteritis and diarrhea which subsided spontaneously after one week.

Dunlop, Twedt and Wang[5] described a quantitative method for the estimation of Salmonella in sewage contaminated irrigation water. Several types of Salmonella were isolated from 8 of 11 irrigation water samples examined. The median value of all 11 samples was 0.9 Salmonella per 100 ml. of water.

Ross and Gillespie[6] reported an outbreak of gastro-enteritis affecting 160 of 1250 factory employees and 28 persons in neighboring houses. Examination of the factory drinking water revealed the presence of more than 180 coliform organisms per 100 ml. of water. Shigella sonnei was isolated from 9 fecal specimens from persons attacked. S. flexneri and S. typhimurium were also found in one specimen each. The outbreak was caused by contaminated river water intermixing with the potable supply through a cross-connection. S. sonnei was later isolated from the river water.

An epidemic of acute infectious hepatitis affecting 22 persons occurred in an isolated rural area of Pennsylvania. Farquhar, Stokes and Schrack[7] found the well water on the farm to be fecally contaminated from the nearby cesspool. Infection was apparently spread both by drinking water and by contact.

Seven specimens of sewage effluent from 4 tuberculosis hospitals yielded tubercle bacilli when examined by Kroger and Trettin[8]. Tubercle bacilli in a ground suspension of infected guinea pig organs contained in a collodion bag and suspended in a stream remained viable as long as 48 days. The possibility of the water from the stream receiving the sewage effluents infecting cattle was implied.

In sandy soil, about 10 years was required to oxidize a corpse. Van Haaren[9] found that during decomposition of the body, breakdown products leach out of the soil. Analyses of surface and ground waters of several cemeteries showed that in every case the waters were heavily polluted.

Because Pseudomonas aeruginosa has been isolated from many sources, Ringen and Drake[10] attempted to determine its normal habitat. A selective medium containing pyocyanin was used in studies to establish the incidence of this organism from various natural sources. P. aeruginosa was isolated consistently from sewage and from all parts of the sewage plant except the sludge. Feces from 11 percent of the individuals examined contained the organism. Human feces, therefore, probably served as the inoculum for sewage and should be considered as the normal habitat.

Faneuf and Healy[11] reported that high counts of E. coli were observed in the water of Penacock Lake, the source of Concord's water supply. The E. coli were derived from fecal matter on a picnic area near the screen house. Dosages of 10 p.p.m. chlorine were ineffective in disinfecting the distribution system due to dissipation of chlorine by sediment in the mains. Fifty p.p.m. chlorine produced satisfactory samples.

Emphasis was given the point that present methods of analysis do not reveal pollution until about 5 days after it has occurred.

The antigenic relationship of S. dysenteriae 2 (S. ambigua) and E. coli O group 112a,c were described by Ewing, Hucks and Taylor[12]. The O antigens of these two bacterial types are identical. Various interrelationships among enteric bacteria were discussed. These interrelationships directly contribute to the complexities of water examination and other laboratory tests related to enteric disease.

Sears and Brownlee[13] contributed further evidence in support of the thesis that the normal human harbors both resident and transient strains of E. coli. The resident group comprised one or two strains at any given time. The transient group was often absent and rarely consisted of more than 3 or 4 strains. In infants, resident strains may become well established 10 days after birth. Both the transient and resident strains might change. However, the conditions under which strains were lost and new ones acquired could not be defined accurately.

In storage studies, the various members of the coliform group remained viable for long periods of time in both autoclaved and unautoclaved estuary waters as reported by Buck, Keefer and Hatch[14]. The bacterial cell densities exhibited cyclic changes, involving a decrease and a subsequent increase in numbers, at least twice in some experiments. If it was assumed that field conditions were in general similar to those in the laboratory, coliform organisms, once introduced into an estuary, would remain for a long time provided their number was not reduced by sedimentation, predatory protozoa, etc.

It was shown by Ketchum, Ayers and Vaccars[15] that the effects of dilution, bactericidal action of sea water, and predation accounted for more than 99 percent of the decrease in coliform organisms in the Raritan River. The bactericidal action was the most important process followed by predation and dilution.

Joseph and Shay[16] determined the longevity of E. coli in acid mine waters. The rate of reduction on contact was rapid, but a small number of bacteria survived the 24 hour testing period at a pH 2.0. Factors active in self-purification studies were acidity, toxicity of compounds present, antagonistic action of microorganisms, food supply and ingestion by protozoa. All waters of extreme acidities and of pollution with fecal material and mine wastes, which were examined, supported the growth of a few microorganisms. E. coli was among the bacteria which can sustain acid conditions in small numbers.

The Public Health Laboratory Service Water Sub-Committee[17] studied the effect of storage on the coliform and E. coli counts of water samples. One hundred and fifty one samples were collected from 80 sampling points in England and Wales. One portion of each sample was immediately tested for coliform organisms. Two other portions were stored 20-24 hours, one at room temperature (16° C. + 23° C.) and one at refrigerature temperature (2° C. - 5° C.). Coliform determinations were made by a 70 tube dilution method in which 10 tubes of MacConkey broth were inoculated with each of 7 two fold diminishing volumes of sample. Significant increases in coliform organisms occurred in 23 (15 percent) of the 151 samples stored at

room temperature, and in 10 (7 percent) of the samples stored in the refrigerator. Significant decreases of coliforms occurred in 29 (19 percent) of the samples stored at room temperature and in 26 (17 percent) of the refrigerated samples.

Goetz and Tsuneishi[18] described the chemical and physical nature of the molecular filter membrane as well as several possible applications to water bacteriology. They listed several advantages of the molecular filter techniques over present Standard Methods of bacterial analysis as; nutrients may be removed or changed at any time during incubation; different sections of the same filter deposit may be exposed to different nutrient media; saves time and uses less equipment; permits better and faster differentiation of bacteria; and provides permanent records in the form of preserved filter discs.

Clark and Kabler[19] found that membrane filter procedures for the bacteriological examination of water gave promise of providing reductions in time, material, equipment, labor, and space required. Coliform determinations by the membrane filter procedure required approximately 18 hours instead of the present 3 or 4 days. The same authors[20] also reported that by use of enrichment or inhibitory media, or both with the filter, the growth of particular groups or species could be encouraged.

Goetz, Gilman and Rawn[21] presented the results of tests using preimpregnated dehydrated nutrient pads with the membrane filter. Parallel tests for the coliform group on littoral waters (Pacific

Ocean) using the membrane filter and Standard Methods serial dilution with lactose broth (M.P.N.) procedures showed comparable results.

Two independent incidents aboard Navy ships in which fecal organisms failed to produce visible colonies on S.S. agar, after 18 to 24 hours incubation at 37° C. were recorded by Wharton[22]. This "no growth" phenomenon showed a definite tendency toward repetition from the same individual. It rarely occurred in cultures from those persons having had demonstrable shigellosis while it tended to occur frequently in those persons in the same environment who apparently escaped shigellosis. The author suggested the possibility of bacteriophage or non-pathogenic organisms commonly found in the bowel, as responsible by producing antibiotics.

Weaver and Boiter[23] isolated from waters of Fayette County, Kentucky wells, 15 strains of B. subtilis and 13 strains of B. cereus, that were antagonistic for E. coli. Almost all of the strains of B. subtilis produced antibiotic substances active against S. flexneri, S. typhosa, S. paratyphi, and Micrococcus pyogenes var. aureus. These results indicate that Bacillus spp. may affect the longevity of enteric organisms in surface waters.

The effects of bacteriophage on the survival of Enterobacteriacea in polluted waters from various sources were studied by Guelin and Gozdawa - Le Bris[24]. They found that the bacterial count decreased progressively for the first few days and then dropped abruptly on the seventh day. The sharp decrease was accompanied by a rapid clearing of the medium. This clearing phenomenon was not observed in autoclaved waters. Salmonella phage I from large isolated bodies of water was

specific, while the phage I from small bodies of water was multivalent and attacked the coli-typhoid-dysentery group of organisms.

Bacteriophage for Clostridium welchii has been isolated by Guelin[25] from polluted water in quantities proportional to the degree of pollution. The numbers of Cl. welchii, and consequently of the bacteriophage, are often lower than the numbers of E. coli present. The bacteriophage can reduce the bacterial population by lytic action and under natural conditions might assist in the purification of polluted water.

When studying silver compounds as water disinfectants, Palster and Brasdova[26] observed best results with a complex Na-Ag chloride, called Sag I, which decomposed in water to give colloidal silver chloride.

Riehl, Weiser and Rheins[27] reported that E. coli, S. typhosa and S. montivideo do not survive prolonged exposures in waters of high pH maintained by addition of excess lime. Most of the test organisms were destroyed by exposure of slightly over 4 hours, at a pH range of 11.0 to 11.5 and at a temperature of 15° C. Freshly isolated strains were more resistant than the same species propagated several months on culture media.

Elemental iodine is an efficient disinfectant of water. The amounts required to kill 13 strains of test organisms at varying conditions of pH and temperature were determined by Chambers et al[28]. The bactericidal action of iodine resembled that of chlorine in that: greater activity accompanied higher temperatures; lower activity was

exhibited at higher pH ranges. S. sonnei and S. flexneri I appeared to be somewhat more resistant than the E. coli strains studied.

Simulated and authentic nitrate-bearing well waters were prepared by Tubiash[29] at levels ranging from 0-240 p.p.m. nitrate-nitrogen. These waters were seeded with the equivalent of minimal and relatively heavy pollution of E. coli; A. cloacae, A. aerogenes and a mixture of the three organisms. Markedly ambiguous reductions in M.P.N. were obtained with heavily seeded waters at levels of 100 p.p.m. nitrate-nitrogen and over. Equivocally negative M.P.N. values were obtained with the lightly seeded waters at levels of 100 p.p.m. nitrate-nitrogen and over. Bacteriologically nonpotable nitrate-bearing waters may erroneously appear potable when subjected to the Standard Methods presumptive test because of the inhibitory effect of the nitrates on the production of visible gas by members of the coliform group.

Kichatova[30] has recommended the use of rosolic acid medium for the determination of fecal contamination in water. When used in conjunction with a yeast lysate growth stimulent, useful results were obtained in 12 hours.

Using conventional methods for culturing molds, Harvey[31] recovered 21 species of "water molds" from 500 samples of stream bottom, stream bank soil, and stream water. Most of the 21 species isolated preferred habitats free of pollution. Ten species were found in habitats of partial pollution. Only two species were found in habitats considered heavily polluted.

Findlay[32] described a growth of Armillaria mellea 10 feet long in the Carlesmoor water carrying tunnel leading out of Roundhill reservoir, England. Another growth 30 feet long was found in the same tunnel about 7 years earlier. Nutrients for the growth of the fungus were probably derived from the clean water.

An earthy odor produced by Streptomyces in water was reported by Ferramola[33]. Waters of the river Plata occasionally have earthy odors which usually disappear in a few days. Streptomyces grow in the river bottom sand exposed to dry southwest wind. This growth in the presence of vegetable wastes and carbohydrates caused the odor which was absorbed by the returning water when the wind abated.

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Biology

Industry now realises that an adequate waste treatment policy considers the biological health of streams as well as the construction of adequat e treatment facilities[1]. The standard sanitation yardsticks are being re-evaluated and more realistic biological indices are being considered.

Practical biological techniques can distinguish degrees of pollution; and aquatic organisms can indicate a wide range of stream conditions from healthy to grossly polluted[2]. Mills[3] suggests that studies of fish life are of interest and value in evaluating the biological effects of stream pollutants.

A valuable textbook for those interested in stream pollution is that of Liebmann[4]. The author notes the techniques required for the examination and evaluation of biological conditions in water supplies, fishing waters, sewage, and waste waters. The section on methods of biological examination includes description of sampling methods useful in various situations and chemical and bacteriological methods of value to the pollution biologist. Other sections deal with organisms associated with different degrees of organic pollution and with some toxic wastes. Greenburgh[5] suggests procedures for sampling river water and observations to be made when fish kills have occurred.

Mackenthun[6] and Newcombe[7] review the effects of pollutants on the ecology and animal life in streams. The zones of an unpolluted river are classified by Huet[8] according to the predominant fish species. The effects of pollution on the streams are discussed and the typical plants and animals of the various zones of a sewage polluted stream are listed. The chief effect of toxic wastes is a reduction in the numbers and kinds of animals. Mann[9] divides wastes harmful to aquatic life into three main types, those from the chemical industries (coal mines, cement works, soda factories); those containing toxicants (metallic wastes and coking wastes); and the organic wastes.

Stopford[10] found that a discharge of sewage into an estuary may have a strong local effect on aquatic organisms. The normal fauna was, however, not affected adversely during the hot summers. Thomas[11] reported that the Turlersee, Switzerland, which before pollution by the effluent of a cheese plant and by agricultural fertilizers contained adequate oxygen at all depths, now displays a marked deoxygenation of its deeper water. Adequate oxygen is limited to the upper strata, plankton is restricted to a few species and the lake water is now unfit as a source of water supply. Similarly, Lake Zurich[12] has been made eutrophic because of domestic wastes. Fish populations have been damaged and the use of the lake as a water supply has been limited. On the other hand, Gross[13] showed that the controlled fertilization of a sea-loch has resulted in a greatly increased growth rate of fish because of the stimulus to plankton organisms.

Several valuable papers on the methods and apparatus used to conduct bioassays of toxic substances to fish have appeared. Tomiyama and Inouye[14] describe an apparatus which maintains a constant supply of the pollutant and of various acids and alkalies to maintain a fixed pH. Herbert[15] discusses the objectives of bioassay procedures with fish, the effects of the numbers of fish in fixed volume tests, advantages of constant flow systems, and outlines an apparatus which can test fifty fish at one time. Also mentioned are the effects of low D.O. and the chemistry of the diluting water on the toxicity of substances. This comprehensive paper also mentions methods for the interpretation of results, discusses variations in resistance among fish and the effects of acclimatization of the fish on the results of bioassay procedures. Wuhrmann[16] also considers various factors that influence the results of bioassays with fish. DeSavelle and Hubault[17] describe bioassay techniques used in France and give toxicity data for chlorine, chlorides, ammonia and alkalies. Vivier[18] recommends supplementing with laboratory bioassays, tests for toxicity made by suspending caged fish in streams suspected of being polluted. Several summaries of the published data on the toxicity of industrial wastes and their components have been made available. McKee and Gilman[19] compiled from the literature, data on the toxicity of hundreds of substances to fish, aquatic life, livestock, shellfish, and wildlife. LeClerc and Devlaminck[20] list the toxicity to fish in both distilled and hard water of thirty-three inorganic and organic substances. Mackenthun[21] tabulated the toxicity to fish and invertebrates of 217 inorganic and organic substances, industrial wastes, and other substances discharged into streams.

Kubota[22] found that fish eggs could be hatched at a pH range of 3.8-10 but that the optimum range was between pH 6-7.2. Malformed young were hatched in strongly acid or alkaline waters. Jones[23] noted that at low temperatures (13° C.), sticklebacks could not detect water of low D.O. and distress symptoms were slow to appear. At 20° C., distress is so prompt that fish would not swim into water with a D.O. of 2.0 p.p.m. Minnows and trout were found to react similarly. Privolnev[24] observed that young Atlantic salmon fingerlings of different ages varied in their tolerance to waters of low D.O. Forty-day-old fish are restricted to waters having over 3.5 p.p.m.; whereas 110-day-old fish were more tolerant and could survive in waters with 1.0 p.p.m. and higher. Lassleben[25] noted that carp raised in ponds in which the oxygen content was 150 percent of saturation or higher had a high frequency of maxillary disease and dropsy. Fish were healthy in ponds in which the oxygen content reached 125 to 150 percent saturation. The author believes that an abnormally high D.O. is dangerous to the health of fish. Egusa[26] investigated the diseases in fish caused by a supersaturation of nitrogen in an artesian water supply.

Scheuring and Stetter[27] found that carp, perch, and trout were killed in 1-5 p.p.m. chlorine within 15-72 hours. The toxicity of chlorine to tadpoles, crustacea, snails, leeches, and some plankton organisms was also determined. Corti and Weber[28] studied the activity of trout in an ammonia solution. An apparatus called a "Tarachograph" was developed to record electrically the reactions of fish in toxic

solutions. Cremer[29] and Eden, et al[30] determined the toxicity to fish of H_2O_2, hydrazine, and methyl alcohol which are wastes resulting from the testing of rocket engines. 40 p.p.m. H_2O_2 was toxic to fingerling rainbow trout, 0.7 p.p.m. hydrazine hydrate caused a loss of equilibrium in less than 24 hours, and up to 8100 p.p.m. methyl alcohol was harmless in 24 hours. Rainbow trout were unaffected by 10 p.p.m. of formaldehyde in three days but 50 p.p.m. killed within one to three days. 500 p.p.m. of ammonium sulfate was toxic to fish; and fish food organisms were killed by lower concentrations[31]. 2500 p.p.m. of ammonium thiocyanate was lethal. Wuhrmann, Zehender, Woker[32] emphasize that the toxicity to fish of solutions of ammonium salts depends mainly on the amount of non-ionic free ammonia which can be determined from the concentration of the solution and the pH. Woker[33] found that the toxicity to fish of various concentrations of ammonia was not dependent upon the water temperature. In experiments, the D.O. was maintained at 9-10 p.p.m. and the temperatures of the various test solutions were 10, 14, 17 and 25° C.; the same mortalities were observed at all temperatures. Wuhrmann and Woker[34] found that the threshold of toxicity to minnows was around 1.0-1.2 p.p.m. NH_3, trout fry were sensitive to 0.3-0.4 p.p.m. NaCN at 0.33-0.35 p.p.m. killed minnows in 2.5 hours. Solutions containing mixtures of NH_3 and CN are more toxic than either solution alone. Authors believe that these toxicants penetrate through the gill membranes. Czensny[35] found that the HCN in metal-working wastes is toxic to trout in concentrations of 0.1-0.15 p.p.m. HCN. Instances of fish kills due to cyanides in industrial wastes were reported from Germany and the United States[36][37][38].

LeClerc and Devlaminck reported on the toxicity to fish of the component chemicals of wastes from explosive factories[39] and from tanneries[40]. The minimum lethal dose to fish that had been immersed for 6 hours in distilled and tap water solutions of the various waste components was determined. These include: mono- and dinitrophenol, TNT, dinitrocresol, mono- and dinitrobenzene, hydrochloric, boric, tannic and lactic acids, sodium bisulphite, sodium borate, sodium metabisulphite, ammonium chloride, sodium sulfide, sodium sulphate, ammonium sulphate, and chromium sulphate.

Beeckmans and Beaujean[41] also reported on the toxic effects of tannery wastes to fish. After pollution by cotton mill wastes, Dendy[42] was able to find only 3.4 lbs. of fish per acre in Sougahatchee Creek, whereas prior to pollution this creek yielded 41 lbs. per acre.

Siyazuki[43] observed the effects of effluents from a fermentation plant, a brewery and pulp mill upon a landlocked bay. Analyses were made of the effluents, the bay water, and muds. Fish kills observed were attributed to the organic wastes from the plants. Redfield and Walford[44] studied the effects on plankton and fish of the disposal at sea of 4000 tons per day of an acid waste containing ferrous sulfate and sulfuric acid. Although zooplankton in the discharge area were temporarily affected, the organisms recovered when the waste was diluted and no biological harm was indicated.

Scheuring[45] found that trout fry and insect larvae survived several days in a 1.5 to 2 percent solution of sodium sulphate, but

protozoa survived for 28 days. Potamogeton was affected by an 0.5 percent solution while other plants were affected by 1 percent solutions.

Tomiyama and Yamagawa[46] determined in a constant flow apparatus, that sodium sulfide was more toxic at low pH values; 0.5 p.p.m. was lethal at pH 5.2; while at a pH of 8.2, 8.0 p.p.m. was lethal.

Mackereth and Smyly[47] report that the stone-loach, Nemacheilus, died in water containing 0.2 p.p.m. or over of Cu. Paul[48], in a discussion of the biological effects of water pollution in California, notes that certain resident trout populations have become accliminated to copper concentrations that kill introduced hatchery raised fish. Studies also indicate that some common household detergents may be toxic at levels of 10-20 p.p.m. Mackenthun[49] and Mackenthun and Cooley[50] demonstrated that the copper content of mud at the bottom of heavily treated Lake Monona, Wisconsin, is far below that which will kill bottom dwelling organisms. 9000 p.p.m. Cu in bottom muds was found to be toxic to bottom dwelling fauna.

The toxicity of water in contact with zinc coated metals is markedly higher in soft than in hard waters[51]. Severe losses of trout eggs and fry in an Australian hatchery were found by Affleck[52] to be due to zinc (0.04 p.p.m.) dissolved by slightly acid water (pH 6.0-6.8) from galvanized iron pipes. LaRose[53] contends that the mortalities of fish in trout ponds were due to small amounts of Fe (about 1 mg. percent). Microscopic examination of the gills indicate the penetration of a semi-colloidal basic iron salt into the gill tissues.

Kosima and Tomiyama[54] analyzed waters in trout hatcheries for many ions in an effort to correlate water chemistry and mortality of young rainbow trout. It was found that the mortalities are directly proportional to silicate content and inversely proportional to calcium content of the hatchery waters. By using radioactive calcium, Lovelace and Podoliak[55] showed that small rainbow trout absorb calcium through the gills from the surrounding water. The calcium is then distributed through the body by the blood stream. Kaemmerer and Erichsen[56] found that nickel was more toxic to fish than Fe and Mn. Mn seemed to be slightly antagonistic toward Ni. Effluent from lead mines were not only toxic to fish but the precipitates also cover spawning grounds and destroys fish food organisms.

Specht[57] tested the toxicity of chemicals used in the flotation processes of the phosphate industry and found that tall oil was the only agent liable to be toxic to fish.

Gillette, Miller and Redman[58] tested 51 organic compounds, mostly alcohols and amines, to determine their toxicity to fish. The most toxic compounds were simple alkyl amines, sodium hydrosulfide, phenol, ammonium hydroxide, and 1, 3, dibutylthiourea. The toxicity of alkylamines and ammonium hydroxide was reduced by adjusting the pH of the test water near neutrality.

Fish kept in sublethal concentrations of Kraft pulping wastes did not develop any observable pathology of the gill and liver tissues[59]. Haydu, Amberg and Dimick[60] studied the toxicity of Kraft pulping wastes

and their components to typical anadromous salmonid species of the Pacific northwest. Tests were conducted in aquaria and in an artificial stream designed to simulate a natural stream environment. Aquatic insects were also tested.

Lindenberg and Gary-Bobo[61] determined that the threshold concentrations of various aliphatic alcohols as determined by the narcosis of fish was not a function of the length of the carbon chain of the alcohols but varied according to the pharmacodynamic action of the various compounds. The narcotizing concentrations of the various alcohols were not the same in different fish species. Dilutions at the threshold of physiological action and the concentration at the abolition of reflexes in fishes for several hydrocarbons and their polar derivatives were also determined[62]. It appears that water solubility of a compound affects the value of the threshold activity only when the solubility is above a minimum value.

Maramorosch[63] found that fish were killed when placed in water containing cellulose acetate sheets. The plasticiser, diethyl pthalate, which diffused into the water was the toxic agent. Raffy[64] found that certain fish placed in 0.25 to 1.5 percent alcohol showed an increased oxygen consumption while other species showed a decrease. Sollman[65] found that hydroquinone in water is 100 times more toxic to goldfish than phenol. Tertiary butyl catechol was also highly toxic. These substances act by inhibiting many of the autocatalytic processes of fish. It was found[66] that fish subjected to 0.1 p.p.m. or more of S-guaiacazulene died of anoxemia within six hours.

Bogrenreider[67] found that intravascular blood coagulation occurred in fish poisoned by phenol or nitrobenzene. Coagulation occurred in half of the fish killed by dinitro-orthocresol. No coagulation was found after carbolineum poisoning.

Aust[68] described the danger to fish of sprays containing carbolineum, mineral oils, and insecticides. Fish kills have been caused by washing spraying equipment in streams. The effect of arsenic and arsenic compounds, pyrethrum, derris, dinitro- orthocresol, DDT, and the newer insecticides were also discussed. Aust[69] states that DDT at a concentration of 19 p.p.m. is toxic to fish. An indirect action is the destruction of natural fish food by the insecticides. Bandt[70] found that the insecticide hexachlorohexane is a nerve poison, but acts so very slowly on fish that it is probably not dangerous. It is, however, very toxic to fish food organisms. Ginsberg[71] determined that dieldrin was twice as toxic to fish as aldrin; 0.25 p.p.m. of aldrin and 0.125 p.p.m. dieldrin killed all the fish tested; 0.25 p.p.m. DDT killed all fish tested. Fish kills have been reported in Oklahoma[72] where aldrin and toxaphene has been used as insecticides. In 10 hours, 0.5 p.p.m. aldrin kills many fish species. The toxicity of aldrin persists in water from four to five days.

Huet[73] reports that substances toxic to fish are found in the humus formed in spruce forests. This ultimately results in a depletion of aquatic life and the disappearance of fish in streams draining spruce forests. LeClerc and Devlaminck[74] investigated the toxicity to fish

of the resins and terpenes from conifers. Most toxic resins were those of larches and least toxic from cedars of lebanon, Corsica pine and Thuja. Bandt[75] found the extracts of needles, twigs, and fruit of arborvita and juniper to be toxic to fish and those of Taxus are not toxic.

Duuren and Groenewoud[76] made a chemical investigation of the tuber of Neurotanenia edulis which is poisonous to fish. They extracted and determined six organic compounds from the tuber. The toxicity of these compounds were determined; two of the six were definitely toxic and one of these exhibited physiological action similar to rotenone.

Petard[77] lists some plants containing saponins, rotenones, and other substances toxic to fish.

Mortalities of animals attributed to toxic algae have been reported from various localities in North and South America, Africa, and Australia. Olson[78][79] suggests that algal toxins might be the cause of unexplained dysentery epidemics in Ohio and Potomac basins and might be correlated with the condition known as Haff's disease in Europe. Scott's[80] review emphasizes that fresh algae are more toxic than decomposed algae and that frozen and dried algae are most toxic. The chemical nature of the toxin is unknownbut it is secreted by the algae in the surrounding water, killing animals that drink the water. On the other hand, McLeod and Bondar[81] while investigating the death of domestic animals that followed drinking water that was blooming with Alphanizomenon flos-aquae, killed mice and rats by allowing them to drink a suspension of lake water and algae. The lake water was non-lethal after the algae had been removed.

Ingram[82][83][84] prepared a series of selected bibliographies of value to those interested in the biological problems of water supply and water pollution. Titles listed deal with water treatment, water pollution, plankton nuisances, algal control, and the identification of plants and animals found in polluted streams.

Ingram and Palmer[85] present in detail, methods of collecting, counting, identifying and recording plankton with the intention of aiding water plant operators in predicting and preventing plankton blooms. Moore[86] attempts to obtain from a statistical examination of a large number of data from several sources, some evidence of the magnitude of errors present in plankton counts and from this information to estimate the reliability of the counting procedures used to enumerate microscopic organisms in water.

Pearsall[87] emphasizes that a knowledge of aquatic biology is of importance to those concerned with water supplies. For example, vigorous algal growth may reduce the water hardness as much as a third. Algae in improperly designed reservoirs can create operational difficulties. Wohlschlag and Hasler[88] studied the populations of blue-green algae in Lake Mendota to determine conditions leading to algal blooms. Algal density was determined by measuring chlorophyll concentrations. Verduin[89] found that photosynthesis by phytoplankton in Lake Erie can be measured by using the changes in pH as an index of the removal of CO_2. A high correlation was found between the volume of algae and photosynthesis rate; and it is suggested that the volume of algae be taken as an index of productivity.

Stone and Abbott[90] found that when fresh sewage was added to water containing green micro-organisms any dissolved oxygen soon disappeared, but within 48 hours oxygen was again present and increased to successively higher levels each day with decreases at night. The effect of these variations on stream purification is discussed. Ludwig and Oswald[91] studied Euglena in sewage polluted ponds. In ponds under favorable nutritive conditions (highly polluted) the organisms are vigorous and produce an excess of oxygen. Euglena serve as a source of food to zooplankton and fish.

Phinney[92] outlines some of the fundamental studies necessary for an elucidation of the role algae play in the ecology of polluted and unpolluted streams. Some phytoplankters use soluble carbohydrates, fat soluble organic compounds, and salts of organic acids, and nitrogenous organic compounds. Sorenson[93] found the alga Hydrodictyon, which is normally rare in Sweden, to be abundant in one river which is polluted by sewage and trade waste waters. Analysis of the water from various points along the river are given. This alga occurs in that stretch of the river which has recovered from the effects of pollution. The toxicants and sludge in the wastes of Paris change the character of the plankton in the River Seine[94]. Other variations in the plankton production can be correlated with variations in the depth of water, light penetration, and water temperature.

The addition of salts containing nitrogen and phosphates into waters containing phytoplankton leads to an increased D.O.[95]. The addition of superphosphate and ammonium nitrate into reservoirs and lakes gives similar improvement in photosynthetic activity which lasts for several days after the addition. Sawyer[96] points out that the increasing use of detergents, many of which have high phosphate contents, may increase algae problems in water. Average contents of phosphate in sewage has doubled in the past ten years.

Topinska-Luchter[97] investigated the micro-flora populations in waters with various amounts of hydrogen sulfide. In waters containing 20-50 p.p.m. hydrogen sulfide an abundance of sulfur bacteria of various types as well as blue-green algae were present. Waters containing over 50 p.p.m. hydrogen sulfide contained only motile red sulfur bacteria.

Although the city of Lucerne had stopped polluting the water of Red lake for about 12 years, the oxygen content in the lake was still critical[98]. There was only 0.16 p.p.m. D.O. at 5 meters and none at 15 meters. The plankton species consisted chiefly of Oscillatoria and Leptothrix. Jaag[99] found that the heavy contamination of Swiss lakes has reduced their oxygen content. FeS has been deposited, Oscillatoria rubescens has become predominant, and the fish populations have suffered.

The radioactivity of the plankton in the Columbia River below the Hanford Works was considered to be insignificant. The radioactivity of the plankton carried by the river past Hanford during July was 0.6 curies per day[100].

Surfaces coated with a newly patented rosin amine algicide[101] kills algae and inhibits regrowth. Fitzgerald et al[102] screened 300 organic compounds for toxicity to bloom producing blue-green algae. Several quinone type compounds are toxic in concentrations of less than 1 p.p.m. The chemical, 2,3 dichloronaphthoquinone, is lethal in concentrations as low as two micrograms per liter. This compound is selectively toxic to bloom producing algae and is non-toxic to most green algae and higher plants. In short term tests, it was found to be non-toxic to fish and other aquatic animals in concentrations used for algae control.

Flentje[103] discussed the use of phytocides in water weed and algae control. Snow and Iantosca[104] used copper sulfate for the control of a fishy taste in reservoir water caused by Uroglenopsis. They chopped holes in the ice and applied the copper sulfate at a concentration of 0.06-0.90 p.p.m. Williams[105] found that 15 p.p.m. of various quaternary ammonium compounds controlled the growth of algae. 5 p.p.m. Arquad S is effective against Oscillatoria. Bervoets[106] tested the toxicity of hexacyclohexane to plankton. It was found to be far more effective in running water.

In 1908 and 1909 Kolkwitz and Marsonn in their classic work, classified aquatic organisms according to the condition of the water of which they were typical. In this revision, Kolkwitz[107] has further developed this classification and lists plant and animal saprobes with descriptions of species and the conditions of which they are typical.

Ferramola[108] found that the earthy odor of Plata river water is caused by the growth of Streptomyces in river bottom and exposed by drying southern winds. The odors are absorbed by the returning water. The dryness of the air, aeration of the soil, presence of vegetable wastes and other carbohydrates all favor the development of the streptomyces. Deuticke et al[109] review the causes of the tastes and odors produced by algae. They found that the ether soluble lipoids contained in three different algae vary in composition. The amounts of essential oils obtainable by steam distillation also vary widely.

Harvey[110] studied the distribution of fungi in the various polluted zones in the watersheds of the Great and Little Miami River valleys. Some species were always absent from heavily polluted waters, others were found in moderately polluted areas. Only Aphanomyces showed an affinity for polluted water.

Gaufin and Tarzwell[110a] made intensive studies of the bottom invertebrate fauna found in the various pollutional zones of a Midwest stream contaminated by domestic sewage. The numbers and kinds of bottom organisms were correlated with the pollutional zone, season, and physical and chemical conditions in the stream.

Wastes from Buna works contain organic materials which stimulate heavy fungus growths downstream from the plant effluent. Studies are being made to determine these nutritive substances preliminary to treatment at the plant(111).

Mohr(112) discussed protozoa as indicators of pollution but he feels that protozoa along with other animals are better indicators of pollution than protozoa alone. Protozoa in polluted marine waters are similar to species found in polluted fresh water. They are sensitive to toxicants and are reduced and eliminated in their presence. Protozoa are, therefore, suggested as bioassay organisms in the detection of toxic wastes.

Vinogradov(113) determined that the small consumption of oxygen by zooplankton cannot affect significantly the oxygen content of the water in reservoirs where replacement from the atmosphere and photosynthesis can operate. In the deeper layers, an oxygen deficiency can be caused by the metabolic demands of these animals. The oxygen consumption for some plankton crustaceans was determined. Carillo(114) reported that microcrustacea mostly Cyclops and Diaptomus were clogging the filters of the Buenos Aires water works. 20 p.p.m. of copper sulfate killed all the crustaceans within 24 hrs. Treatment of the raw water with chlorine sufficient to leave a 1.5 p.p.m. residual chlorine reduced the number of crustacea after coagulation by 72-81 percent. Coagulation alone reduced the numbers of crustacea by 22-37 percent. Zischkale(115) established the tolerance of several aquatic crustaceans, mollusks, and insects to rotenone, 2,4-D, 2,4,5-T, and sodium arsenite.

Negoro[116] surveyed the physical, chemical and biological characteristics of the acid lakes and streams of volcanic origin in Japan. pH of the lakes vary from 3.5-5 and of the springs 1.2-3.2. These waters are highly mineralized; sulfur oxidizing bacteria are abundant, and algae are scarce.

Gray[117] studied the association between ciliate protozoa and algae in a chalkstream. Although there was no close correlation between total bacterial numbers and total numbers of ciliates present, the highest bacterial numbers occurred where diatom eating ciliates were dominant. Bacteria eating ciliates were correlated with the presence of Gram negative rods in the bacterial flora while Gram positive rods were correlated with the presence of diatom eating ciliates.

Kunts and Wells[118] demonstrated the toxicity of dinitro-o-cyclophenyl and its dicyclohexylamine salt to mollusks. These were toxic at 3-5 p.p.m. and were not adversely affected in their action by water of high organic content. These are best used in conjunction with copper sulfate in schistosome vector control.

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Chemistry

Observations on the varying characteristics of a group of ponds and lakes into which yellow muddy waters flow lead to scientific studies by the Oklahoma Agricultural and Mechanical College at Stillwater, Oklahoma[1]. One of the important factors contributing to a clarification of the muddy (montmorillonite clay) waters was found to be increased acidity (CO_2 production) and possibly the coagulating effect of organic decomposition products. Coagulation of turbidity was confirmed in laboratory jar tests by adding dry or green grasses. An amount of green vegetation equal to three times the weight of suspended clay cleared impounded waters without critically depleting dissolved oxygen and without destruction of fish life. Taste and odor problems were not considered.

Taste and Odor.

The prevalence of objectionable tastes and odors in water supplies of the Missouri and Mississippi Rivers during the spring runoff was claimed[2] to be due to the natural decay of vegetable matter. Various oxidative processes and activated carbon treatment were applied with variable success.

Taste and odor problems from industrial wastes were reported by Welch[3]. Periodically a mixture of acrylic type chemicals and coal tar chemicals in the Delaware river water cause taste and odor problems at the Torresdale water plant. The taste and odor was effectively controlled in

laboratory treatment with 70 p.p.m. activated carbon to reduce the threshold odor from 20 to 5, followed by chlorination and dechlorination to a threshold value of 1.5. The acrylic odor was removed, but a slightly musty odor persisted. Prechlorination followed by activated carbon treatment was not as effective.

A chemical waste produced a strong taste in the river water of the London, England area[4]. One water plant, using sand filtration and carbon treatment, did not remove the taste, whereas another plant, using dual filtration and carbon, removed it completely.

Manson[5] reported that 4000 gallons of kerosene was accidentally dumped in the Mascoma River when a trailer-truck overturned. The resulting intense taste and odor of the Lebanon, New Hampshire water supply was solved by the use of 70 p.p.m. of active carbon.

Two case histories were given by Muller[6] where considerable quantities of gasoline escaped into the ground. A gasoline odor was detected in wells to a maximum distance of about 3 km. Some persons can detect gasoline in water at a concentration of 1 p.p.m., and it becomes very noticeable at 10 p.p.m. In one case, the gasoline contained tetraethyl lead and the lead was present in a concentration of 0.5 p.p.m. Nitrates were reduced in well water containing gasoline. There was evidence of biological or catalytic oxidation of gasoline in soil.

The occasional earthy odor in the water of the river Plata was suspected by Ferramola[7] to be due to streptomyces growing in the moist aerated

river bottom sand which was periodically flooded and from which odors were subsequently leached. The hypothesis was experimentally tested and confirmed.

Trace quantities of organic chemicals in surface waters were recovered for study by Middleton, Braus and Ruchhoft[8]. The chemicals were adsorbed on an active carbon filter. After drying the charged carbon, the chemicals were extracted with chloroform. Group separation techniques and infrared analysis were applied to the extract for a partial chemical identification. The neutral type compounds were found to be principally responsible for taste and odor in water. Application of the technique to industrial waste studies was pointed out.

The contamination of surface waters by petroleum refinery wastes was reviewed by Villar[9], under the following headings: general characteristics of refinery wastes, harmful effects of contamination by these wastes, general requirements for treating liquid refinery wastes, and legal considerations in prevention of contamination.

A countercurrent solvent extraction process was described by Biehl[10] for removing phenol from waste in the catalytic cracking operation of petroleum to reduce toxicity to fish and taste in drinking water. The waste water containing 200 p.p.m. phenol is extracted with 2 volumes of 75 percent aromatics gasoline in 5 stages, to remove 99.9 percent of the phenols.

Dietz et al[11] studied the tumor-producing properties of petroleum fractions applied to the skin of mice. High-boiling (>700° F.) catalytically cracked streams had higher tumor potencies, as do similar fractions of steam-cracked tars. The carcinogenic properties were associated with the aromatic fractions. Precycle catalytic or thermal cracking was suggested as a way to eliminate the high boiling fraction.

Ground Water Pollution.

Wuhrman[12] discussed the purifying action of the soil on polluted water as it seeps into underground sand or gravel strata. The major purifying effect was claimed to be due to the absorptive quality of humus and clay and the biological activity of the top soil. The kind and type of top soil were important considerations in protecting ground water supplies. The pollution of ground water by large garbage and refuse dumps was discussed by Rossler[13]. The water of a battery of wells 10-12 meters deep showed a marked increase in Cl, hardness, $KMnO_4$ consumption, etc., beginning about 10 years after the establishment of a city refuse dump in the vicinity. The water of one well which was "upstream" (along the underground current) from the dump showed no such change in contents. There was no bacterial contamination of the affected wells. This was due to the filtering efficiency of the sand and gravel soil.

Van Haaren[14] reported that surface and ground waters were heavily polluted at a number of cemeteries by the decomposition products which leach out into the sandy soil.

Davids and Leiber[15] reported on ground water contamination from the discharge of chromium-bearing industrial wastes into leaching pits. The concentration of chromium in some well waters was as high as 40 p.p.m. The chromium could be precipitated from the wastes by treatment with ferrous sulfate and lime to reduce the contamination to a level permitting safe discharge of the settled effluent in cesspools.

Chemical Pollution and Control.

A manual was published by the Ohio River Valley Water Sanitation Commission through its Steel Industry Action Committee[16] so that known data on the acid pickling waste problem would be available as a reference to the steel industry and sanitary engineers charged with responsibility for pollution abatement.

Liquid brine discharged from two sites on the Muskingum River, 220 miles from the Ohio River, contributed 1000 tons of chloride ion to the Ohio River in 3 weeks, increasing chlorides from 26 to 47 p.p.m., and increasing hardness from 132 to 164 p.p.m.[17]. Chlorides in Muskingum River varied from 200 to 15,200 p.p.m., sometimes in slugs, and prevented 125,000 people from using the river as a water supply.

Cremer et al[18] reported that waste waters from the testing of rocket motors contain hydrogen peroxide, hydrazine hydrate, and methyl alcohol. Concentrations of peroxide above 40 p.p.m. were found to be toxic to fingerling rainbow trout, and 0.7 p.p.m. hydrazine hydrate caused loss of equilibrium in fish in less than 24 hours. Catalytic decomposition can

be affected by first stirring with 1 p.p.m. Cu as $CuSO_4$ at pH 7 to remove hydrazine hydrate by oxidation, and then with 4 p.p.m. Mn as $MnCl_2$, after adjusting pH to 11 with lime to destroy peroxide, the precipitated Cu and Mn being separated by settling. A final biological stage would be necessary if the concentration of methyl alcohol or formaldehyde was too high.

Extensive fish kills resulting from the drainage from gob-piles at a coal mine was reported by Gross(19). The drainage produced pH values in the receiving stream as low as 2.8. Leachings from the gob-piles were impounded in a 15,000,000 gallon reservoir. Satisfactory control was provided by discharging the impounded drainage in proportion to stream flow.

Bilharz(20) explained the pollution problems concerned with the dewatering of flooded Zn and Pb mines, located beneath shales high in pyrite and marcasite. The problem involved the discharge of a large volume of acid water into stream drainage, river and impoundments. The mine water (pH 2.5) contained 6500 p.p.m. Fe^{++}, 2100 p.p.m. Zn^{++}, 25,000 p.p.m. SO_4^{--}, and 2600 p.p.m. HCO_3^-, and was treated with CaO to pH > 4.5, aerated and settled. Consumption of hydrated lime (200-mesh) was approximately 24 tons per 24 hours.

According to Todd(21), the Wheeling Creek dried up to only pools of stagnant water which had offensive odors. The B.O.D. of the pond water was found to be as high as 35 p.p.m. Sodium nitrate (72 p.p.m.) was added to change the decomposition from anaerobic to aerobic, which affectively controlled the odor for 7 days.

A "highly purified culture" of Pseudomonas was used by Buswell and Pagano[22] to oxidise acetic acid with nitrates as a source of oxygen. The oxygen available for organic waste stabilization was tentatively found to be approximately 49 percent of the weight of sodium nitrate used.

Relatively unpolluted coastal waters around Norway usually contain less than 4 mg. nitrite per cu.m., according to Braarud and Foyn[23]. In the western branch of the inner fjord, furthest from the source of pollution by sewage, the nitrite content of the surface layers was low during summer and higher (5-12 mg./cu.m.) during autumn and winter. The deeper layers were poor in nitrites except in November and April. It was concluded that the high nitrite values obtained for surface samples are characteristic of the highly polluted waters in Oslo harbour throughout the year, and that the nitrite value would be useful as a criterion for assessing pollution in that area. In other circumstances the concentration of nitrite may be more closely related to the effects of biological activity than to direct pollution by sewage.

Langenberg et al[24] considered the amounts of NaCl in Dutch water supplies in respect to their bearing on "saltless" diets. Results of determination of Cl and alkali (assumed to be Na) in the water supplies of the Dutch provinces, published by the State Department for Public Health for the periods 1938, 1943 and 1948/49 are tabulated and discussed.

In studying bactericidal effectiveness of chlorine treatment at high and low pH values, Markaryan[25] found that chlorine treatment does not affect carbohydrates, hippuric acid, and saturated fatty acids, whereas urea amino acids and creatinine forms nitrogen chloro derivatives.

In considering the industrial pollution of the Willamette River, Oregon, Bollen[26] discussed the chemical and physiological needs of stream micro-organisms as the agents of natural purification.

Oxidation parameters.

Lamb and Jenkens[27] reported studies from which they concluded that (a) synthetic organic chemicals are not attacked biochemically in the same manner as sanitary sewage, (b) river water may not be a reliable source of seed or dilution water for B.O.D. tests, (c) acclimated seed is better for B.O.D. determination of synthetic organic chemicals, and (d) more than 5 days incubation may be necessary to estimate pollution loads.

The oxygen photosynthesized by exposure to a definite quantity of daylight, as measured by the hydrogen iodide actinometer, was recommended by Abbot[28] as a means of classifying polluted waters in which chlorophyll-containing organisms have developed. The test was tentatively called an I.O.D. (illumined oxygen demand). It was shown that under certain circumstances of light exposure and chlorella seeding, a sewage effluent with a 5 day B.O.D. of 70 to 80 p.p.m., would produce oxygen in huge excess of the B.O.D.

Cameron[29] modified the Gibson[30] procedure for differentiating between animal and vegetable pollution by reducing the reaction time to 2 hours and doubling the concentration of reagents. The Gibson method[30] is the ratio of the NaOCl chlorine demand to the $KMnO_4$ oxygen consumed.

Moore and Ruchhoft[31] compared methods for the determination of the dichromate oxygen demand and discussed the relation between dichromate oxygen demand and B.O.D. for sewage, pollutedwater and industrial wastes. It was concluded that aliphatic acids and alcohols are oxidized quantitatively by the dichromate oxygen demand test when silver sulphate is used as a catalyst. The usefulness of the method is thereby extended. A satisfactory relation can be established between dichromate oxygen demand and B.O.D. for settled sewage and industrial waste waters containing no toxic materials. In streams receiving domestic sewage, the ratio of dichromate oxygen demand to B.O.D. gradually increases as the stream becomes biologically stable.

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B.O.D. and Oxygen Sag

Widespread realization that photosynthesis frequently is the most important factor in determining oxygen sags is the most significant development of the year in this field. Stone and Abbott[5] presented evidence of overall positive contributions of oxygen as the result of photosynthetic activities, showing that oxygen produced by illuminated green microorganisms would not be equalled by the respiration of those organisms when in the dark. Abbott[1] presented test procedures designed to make allowances for photosynthesis in estimating stream loading by effluents. He concluded that conditions are so complex in rivers that no test can be devised to accurately reproduce them, and stated further "there is a limit to the realism which can be imparted to modifications of the B.O.D. test.". Nusbaum and Miller[2] in a careful consideration of factors involved in pollution and self purification, stated that "probably the most important source of oxygen available for the oxidation of pollution in San Diego Bay results from the activity of the chlorophyll bearing phytoplankton". Gaufin and Tarzwell[3] presented data on the systematic diurnal variation of D.O. along a small creek with a single important source of pollution. From data which embraced all seasons[4], it was apparent that the diurnal variation of D.O. was of such magnitude that it could not be reconciled to the usual sag curve concept.

Snow[6] studied the effect of partial chlorination of sewages on the ultimate B.O.D., on oxidation constants, and on the initial rate of oxygen consumption. Iz'yurova[7] pointed out the importance of nitrogen, potassium, and phosphorous in relation to biological oxidation of petroleum products. Natermann[8] suggested certain modifications of the method of Fair and Kehr (Imhoff, Taschenbuch, der Stadtenwasserung, 14th ed., 1951) to take into account river conditions such as weirs not contemplated in the original method.

Stream Standards

A comprehensive bibliography (1368 references) on water quality criteria was prepared by the California Institute of Technology[9] for the State of California Water Pollution Control Board.

Standards for sewage plant effluents adopted by the Royal Commission (Eng.) were reviewed by Roberts[10]. It is claimed that the dilution formula developed from the 5 day B.O.D. values does not account for the reaeration capacity of a stream.

Milligan[11] reviewed the industrial waste effluent standards which have been adopted by various States.

Stream Surveys and Studies

A pollution survey of the Wellapa River estuary, supervised by the Washington State Pollution Control Commission, to determine the acceptability of a proposed Kraft-type pulp mill site was reported by Sylvester[12]. Calculations based on minimum river flow, estuary volumes and velocities, mixing (as indicated by chloride concentrations), dissolved oxygen and toxic wastes concentrations, indicate that the location of the plant more than 10 miles from the bay entrance will result in serious dissolved oxygen depletion in the estuary. Constant-rate discharge of waste water is recommended, rather than discharge at ebb tide only, to secure better mixing, as the wastes may remain in the estuary up to 38 days before discharge into a larger volume of dilution water. Graphs, tables and sample calculations are presented.

McDill[13] described the survey of the Maumee River conducted by Ohio and Indiana personnel working jointly toward the abatement and control of pollution in that basin. The results indicate that a 65 percent reduction in the present pollution load is required at the critical flow condition which has been established as the minimum seven-consecutive-days average flow which will probably occur in 20 percent of the years. The major water use in the basin is for public water supplies.

The Ohio River Valley Water Sanitation Commission[14] published a report of a survey on the Wabash River between Keenesburg, Illinois and Terre Haute, Indiana. The survey consisted of two sections: (first) collecting and analyzing hydrologic, waste discharge and water quality data, and (second) evaluating this information in terms of regulatory requirements. Youngquist[15] described the purpose and organization of the Lake Erie pollution survey being conducted by the Ohio Department of Natural Resources. Preliminary investigations have included collection of data on the quality of sediment discharged to the lake by rivers, and bacterial and chemical analyses of tributary rivers. On the basis of information thus far obtained, an estimate was made of the extent and nature of pollution in streams entering Lake Erie and of its effect on the use of the lake waters for industrial and other purposes. The New York State Department of Health[16,17,18,19,20,21] issued a number of reports on surveys made to obtain data necessary to clarify the waters in the various basins under provision VI of the Public Health Law. Generally a summary of past surveys, water index system, hydrology, land and water uses, present defilement, results of survey and the recommended classification, are included in the reports. Tables, graphs and maps are presented.

A detailed method for calculating the oxygen resources of San Diego Bay was described by Nusbaum and Miller[22]. They discuss reaeration from the atmosphere, oxygen produced by chlorophyll-bearing

phytoplankton, and oxygen supplied by tidal exchange. Oxygen demand loadings are presented. Data and supporting material obtained during a survey of San Diego Bay in 1951-52 by the California Department of Health and California Department of Fish and Game, along with long-range water use objectives, are included.

Cabejszek and Wlodek[23] reported on a survey of the Kamienna River in Poland. Physical, chemical, bacteriological and biological analyses of river water show that the upper reaches of the river are not polluted, while the waters below the confluence of the Kamienna and Szewnianka Rivers show pollution. The Kamienna River is very heavily polluted from unsatisfactorily treated wastes from a sugar factory. Stangenberg[24] stated that, except at its source, most of the Bystrzycy River is like an open sewer. For improvement of the river the author includes recommendations to activate all available treatment plants, to design and construct new ones where needed, and to require all plants to submit reports of operation.

The effect of industrial wastes discharge on the Hooghly River in and around Calcutta was discussed by Seth and Bhaskavan[25]. Their survey indicated that paper-mill wastes caused no pollution beyond 50 feet from the outfall and that textile wastes caused no pollution zones. The river supplies adequate dilution for sewage and industrial wastes.

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